Maxwell BOOSTCAP Ultracapacitors

Cost and Energy Savings for Traction Applications

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Ultracapacitor Applications

- **Breaking energy recapture and initial acceleration**

  Stationary and on-vehicle Ultracap power installations that are able to store the braking energy of trains and release it during acceleration. Important cost savings due to significant reduction of primary energy consumption.

- **Voltage stabilization**

  Stationary installation able to maintain a constant voltage level. Installation along the track at critical points where the power net is weak and voltage sags may occur. Costly interruption of the power network are strongly reduced as the installation delivers the energy needed to maintain the power net at constant voltage level.

- **Diesel engine starting**

  Ultracap modules are used to start huge diesel engines of locomotives and diesel-electric trains. The modules are able to supply the needed power in a volume and weight strongly reduced compared to battery systems. Further advantages are the robust construction, the wide temperature range, the high reliability and no maintenance. Reference:

Traction Applications

- **Door actuator**
  Medium size ultracapacitors are used to ensure a reliable functioning of electrical doors.

- **Tilting trains**
  Ultracapacitors are ideally suited to furnish the power needed to activate the tilting system of advanced tilting trains.

- **Support of switch drives**
  Ultracapacitors guarantee the following two demands: Cover the peak power demands and support of switch drives in case of a power outage in the seconds range.

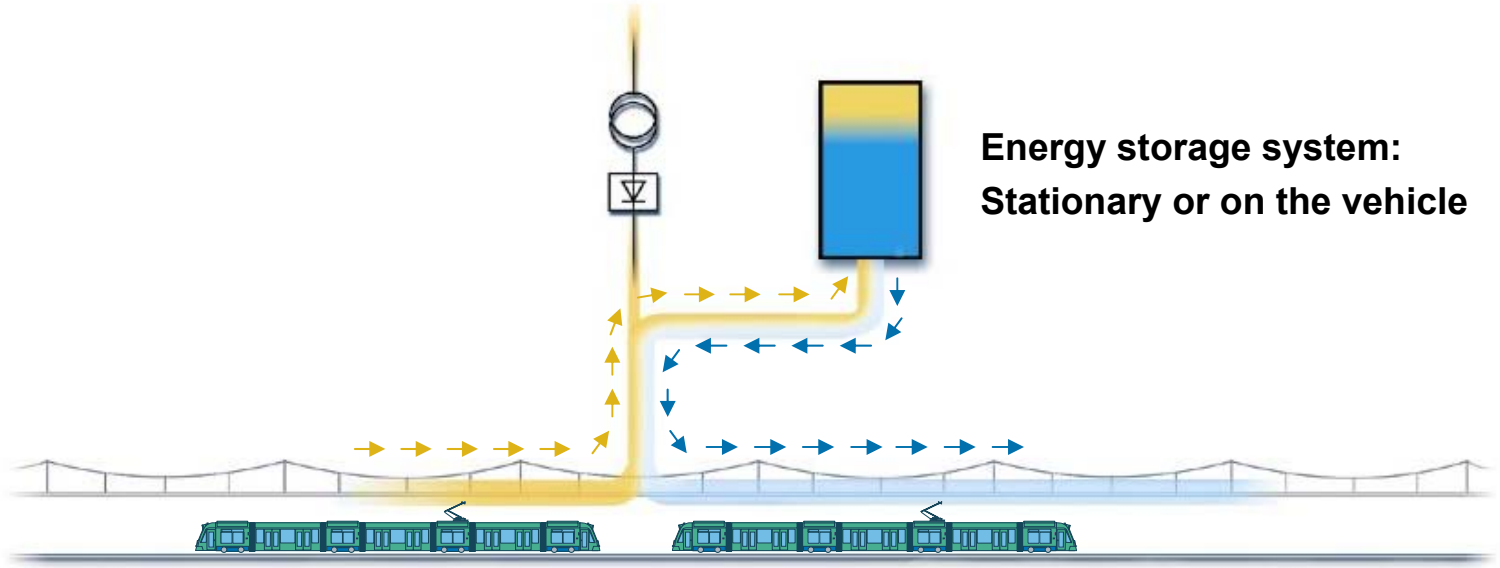
- **Security applications**
  On-vehicle and stationary applications that require power bursts during several seconds. On-vehicle applications are GPS systems, signal horns etc. Stationary applications are automatic acoustic and optical warning units. Here Maxwell small cell ultracapacitors are ideally suited thanks to their high reliability and long lifetime.

Mass Transit Systems Demands

- Provide public transportation for increased demand for mobility due to a steadily increasing population
- Improve energy efficiency of operating systems
  - Energy costs represent the most important part of the operating budget
  - Energy resources to be used optimally for environmental protection and conservation
- Improve network reliability through rail network voltage stabilization

Optimization of the operating costs and the voltage stabilization

Energy Saving Operation



Energy storage system:
Stationary or on the vehicle

Time t_1
Vehicle 1 is braking
→ Energy storage system stores the braking energy

Time t_2
Vehicle 2 is acccelerating
→ Energy storage system delivers the energy

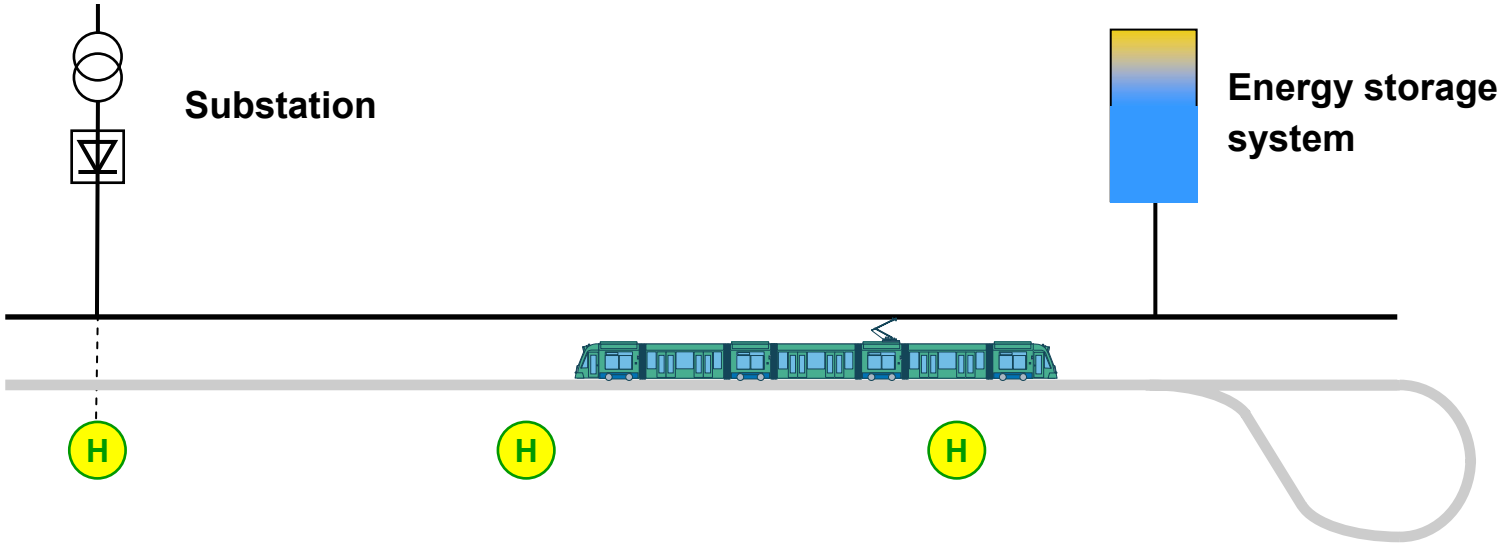
Application: Time shifted delivery of the stored braking energy for vehicle re-acceleration

Solutions: Possible with either stationary or on-vehicle energy storage system

Advantage: Cost savings through reduced primary energy consumption

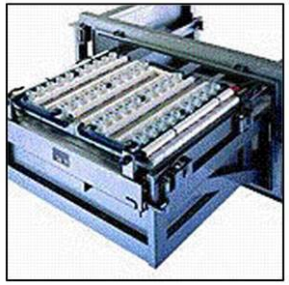
Voltage Stabilization Operation

- Energy storage system is kept at fully charged state
- Energy storage system is only discharged when the network voltage is pulled below a critical level
- Energy storage system is rapidly recharged by braking vehicles or slowly through the DC network
  - Solution: Stationary energy storage system
  - Advantage: Optimization of the network voltage level



Energy Storage Technology Options

- Batteries:
  - \+ very high energy density
  - – bad cycling stability / lifetime
  - – Low peak power

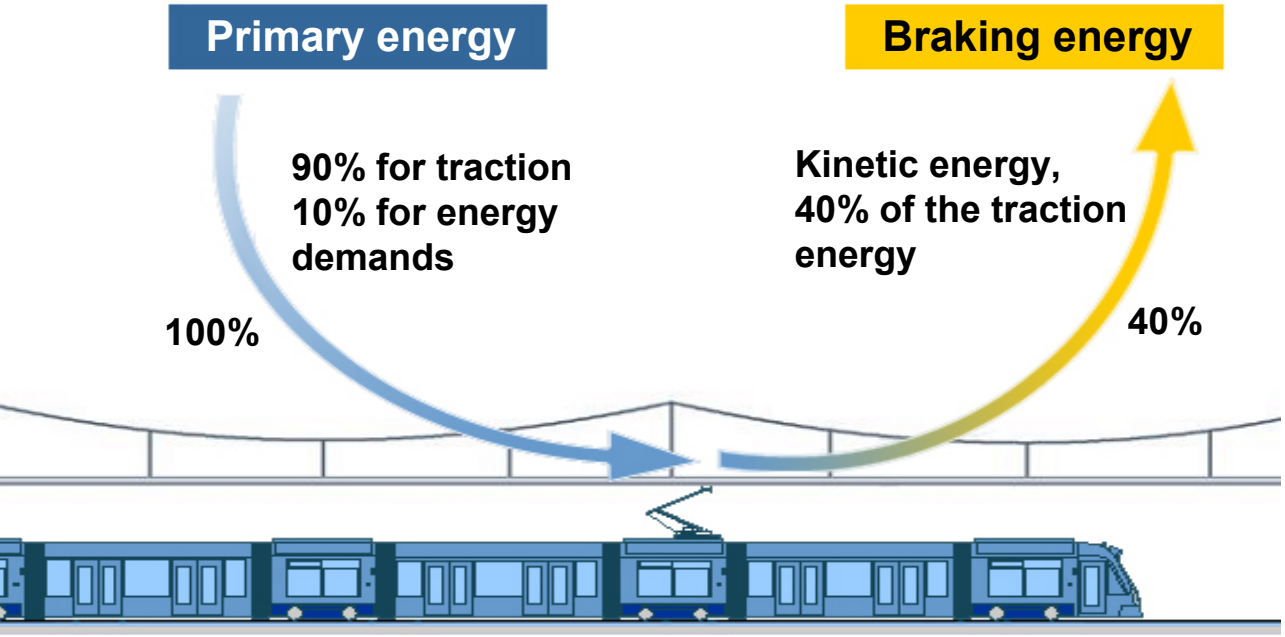


- Flywheel Storage:
  - \+ high energy density
  - – bad cycling stability / lifetime
  - – expensive
  - – low peak power

- Ultracapacitors
  - \+ high energy density and peak power
  - \+ promising price development
  - \+ high numbers of cycles / lifetime (>1.5 M cycles, >10yr)
  - \+ simple technical system (reliability)

⇒ Ultracapacitors are optimal technology

Static Energy Storage System



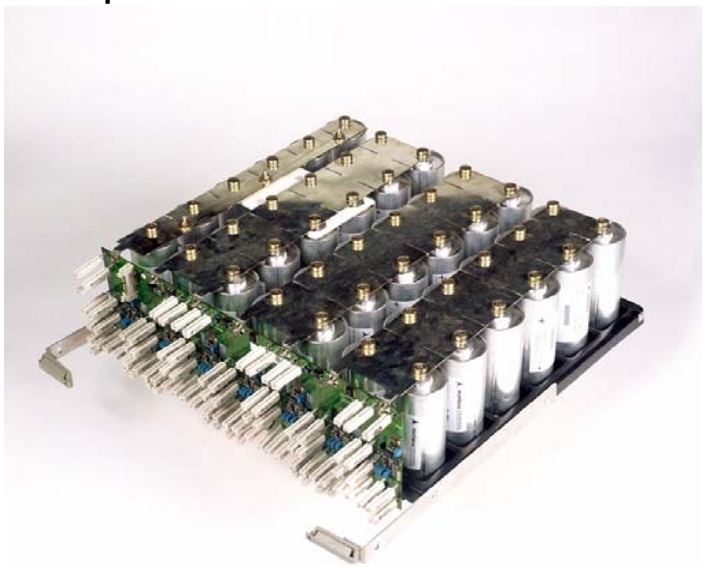
SITRAS® of Siemens TS

Example Savings

- Savings of 320 MWh per year
- Approximate cost of $100 per MWh
- $32,000 savings per station
- 400 potential stations
  - $12.8M in annual savings
  - 128,000 MWh saved per year

SITRAS® Energy Storage System

Nominal voltage	DC 750 V
# of Ultracapacitors	1344
Energy stored	2,3 kWh
Energy saving per h	65 kWh/h
Max. power	1 MW
Capacitor efficiency	0,95
Temperature domain	–20 to 40 °C



ESS rack composed of 42 2600F cells

SITRAS® Installation Examples

Dresden
Hellerau
Full-time service since September 2002

Cologne
Schlebusch
Full-time service since July 2003

Madrid
Sainz de Baranda
Full-time service since July 2003

On-Vehicle Energy Storage System

600 BCAP0008

Weight: 450 kg

Max output: 300 kW

Forced air cooling

Volume: 1900 x 950 x 455 mm

MITRAC™ Energy Saver of Bombardier Transportation

Benefits of an ultracapacitor system

- Energy Savings
  - Very little wasted energy (95% roundtrip efficiency)
- Operational
  - Maintenance free system
  - 10 year life
  - Less wear and tear on brakes
- Cost
  - Product pays for itself several times over

Proof of Concept

The ultracapacitor energy storage system, operational for around 22 hours per day can reduce the annual energy consumption by as much as 500,000 kilowatt-hours or 30%, and reduce the peak power required from the network by 50%